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Competitive Behaviour of Groundnut in Sesame/Groundnut Intercropping System Under Varying Poultry Manure Rates and Planting Arrangement

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Received: February 14, 2013. Accepted: March 20, 2013 Online Published: March 22, 2013

doi:10.5539/sar.v2n3p22

URL: <http://dx.doi.org/10.5539/sar.v2n3p22>

Abstract

Field experiment was conducted during the rainy seasons of 2011 and 2012 at the Teaching and Research Farm of the Faculty of Agriculture, Nasarawa State University, Keffi-Lafia Campus to study the competitive behaviour of groundnut in Sesame-groundnut intercropping system. The experiment consisted of four rates of poultry manure (0, 3.0, 6.0 and 9.0 t ha⁻¹) and two planting arrangement (single alternate row and double alternate row planting arrangement). The eight treatment combinations were laid out in a randomized complete block design with four replications. The results obtained in both the years showed that sesame when grown with groundnut under different rates of poultry manure and planting arrangement appeared to be a dominant crop as indicated by its higher values of Land equivalent ratio, competitive ratio, higher and positive values for aggressivity and area time equivalent ratio. Application of 6 t ha⁻¹ of poultry manure and double alternate row planting arrangement produced the highest values for all the competition indices measured respectively.

1. Introduction

In recent time, there is increasing interest in diversified agricultural production systems to obtain higher yields per unit area through better use of natural resources, minimizing the incidence of insect pests and diseases, greater stability and crop insurance in production under aberrant weather condition, the domestic need of farmers and animals and provide an equitable distribution of farm resources offered by intercropping systems. Intercropping is the practice of growing two or more crops simultaneously on the same piece of land.

Sesame (*Sesamum indicum* L.) also known as beniseed in West Africa, Sim-sim in East Africa is an oil crop belonging to the family *pedaliaceae* grown in both tropical and sub-tropical regions of Africa, Asia and Latin America. It is the most important crop from which semi-drying vegetable oils are obtained and perhaps the oldest crop cultivated for its oil (Onwueme & Sinha, 1991). The importance of sesame lies in its high quality oil which is often referred to as the “queen” of vegetable oil. The outstanding characteristics of sesame oil, is its stability and keeping quality as well as resistance to rancidity (Haruna et al., 2011). Sesame oil is used in making paints, soaps, cosmetics, perfumes, insecticides canned sardine, canned beef as well as for pharmaceutical and ethno botanical uses (FAO, 2002; RMRDC, 2004).

Groundnut (*Arachis hypogaea*) is an oil seed crop having high energy index. It is cultivated particularly for its edible oil and protein rich seeds borne in pods which develop below the soil surface. It used as food and feed in the tropics (Obasi & Ezedinma, 1991). Groundnut (*Arachis hypogaea*) is an oil seed crop having high energy index. On the other hand, leguminous crops are highly nutritious and improve soil fertility by fixing atmospheric nitrogen.

Farmers in Nigeria savanna grow crops in mixture but the yields obtained are generally low because fertilizers (organic or inorganic) are really applied and they do not practice spatial arrangement that will ensure better solar energy interception for higher yield (Chiezey et al., 2005; Haruna et al., 2006).

Work on the competitive behavior of components crops in different sesame-based intercropping systems as

affected by planting pattern have been reported by Sarkar and Chakraborty (2000), Sarkar and Sanyal (2000) and Sarkar et al. (2001). However, no systematic research work has been done so far to explore the competitive behaviour of a component crop in sesame-legume intercropping systems under varying poultry manure rates and planting pattern. This study therefore, seeks to achieve that.

2. Materials and Methods

The study was conducted during the rainy seasons of 2011 and 2012 at the Teaching and Research Farm of the Faculty of Agriculture, Nasarawa State University, Keffi Shabu-Lafia Campus in southern Guinea savanna zone of Nigeria located between latitude 08°30'N and 08°30'E, 18m above sea level. The experiment consisted of four rates of poultry manure (0, 3, 6 and 9 t ha⁻¹) and two planting arrangement (single alternate row and double alternate row). The eight treatment combinations were laid out in a randomized complete block design and replicated three times. The gross plot size was 18 m² (4.5 m x 4 m) while the net plot size was 9 m² (3 m x 3 m).

The experimental area was disc-ploughed and harrowed twice to a fine tilt. This was then followed by ridging at 75 cm apart (between rows) and the field marked into plots and replications. The plots were separated by 1.0 m unplanted boarder while replications were separated by 2.0 m unplanted boarder. The four levels of poultry manure were incorporated into the ridges according to field plan after land preparation and left for two weeks before sowing. The seeds of the two crops were sown on the same day according to planting arrangement (single and double alternate row respectively). A sole crop each of sesame and groundnut were sown at the end of each replication to help determine the performance of the two crops in the mixture. Manual hoe-weeding were done at 3, 6 and 9 weeks after sowing to keep the experimental field weed free. All other agronomic practices were kept normal and uniform for all the treatments.

The competitive behaviors of groundnut in sesame/groundnut association determined are: Land Equivalent Ratio (LER), Aggressivity (A), Competative ratio (CR) and Area Time Equivalent ratio (ATER) which were determined using the following formulae:

$$\text{Land Equivalent Ratio} = \frac{Y_{ab}}{Y_{aa}} + \frac{Y_{ba}}{Y_{bb}}$$

Where, Y_{aa} and Y_{bb} were sole yield of crops 'a' and 'b' respectively, Y_{ab} and Y_{ba} were mixture yield of crops 'a' and 'b' respectively (Willey, 1979).

$$\text{Aggressivity} = \frac{Y_{ab}}{Y_{aa} \times Z_{ab}} - \frac{Y_{ba}}{Y_{bb} \times Z_{ba}}$$

Where, Y_{ab} and Y_{ba} were the individual yields of crops 'a' and 'b' in mixture respectively, Y_{aa} and Y_{bb} were the sole yield of crops 'a' and 'b' respectively, Z_{ab} and Z_{ba} were the sown proportion of crop 'a' and 'b' respectively (McGilchrist, 1965).

Competitive ratio was determined as described by (Willey & Rao, 1980).

$$\text{Competitive Ratio for crop 'a'} = \frac{LER_a}{LER_b} \times \frac{Z_{ba}}{Z_{ab}}$$

$$\text{Competitive Ratio for crop 'b'} = \frac{LER_b}{LER_a} \times \frac{Z_{ab}}{Z_{ba}}$$

Where, LER_a and LER_b are land equivalent ratio for crop 'a' and 'b' respectively while, Z_{ab} and Z_{ba} are the sown proportions of crop 'a' and crop 'b' respectively.

Area Time Equivalent Ratio was determined as described by Hiebsch and McCollum (1987).

$$\text{Area time equivalent ratio} = \frac{(R_{ya} \times t_a) + (R_{yb} \times t_b)}{T}$$

Where, R_{ya} and R_{yb} are relative yield of crop 'a' and 'b' respectively, ' t_a ' is the duration (days) for crop 'a' and 'b' respectively, T is the duration (days) of the intercropping system.

3. Results and Discussion

3.1 Land Equivalent Ratio

In 2011 and 2012, all treatment combinations had LER that is greater than unity (Table 1). This is an indication that there was a yield advantage of intercropping groundnut with sesame over growing either of the crops as a sole. This could be attributed to the fact that component crops differ in their use of growth resources in such a

way that when they are grown in combination, they are able to 'complement' each other and so make better overall use of resources better than when grown alone. Application of 6 t ha⁻¹ of poultry manure and double row planting arrangement produced significantly the highest LER compared to other rates of applied manure and planting arrangement respectively. The lowest LER was produced by the control plots and single row planting arrangement in both years respectively. The higher LER obtain at 6 t ha⁻¹ of poultry manure could be attributed to the fact that highest yield from the two crops were obtained at that rate while the lowest LER produced by the control plots could be attributed to the fact that the lowest yield from the two crops were obtained at that rate. Double alternate row planting arrangement out yielded single alternate row planting arrangement because there was little effect of shading of sesame on groundnut under double row planting arrangement compared to single alternate row planting arrangement hence the higher yield that translated to higher LER in double row.

Table 1. Effect of poultry manure and planting arrangement on the land equivalent ratio of sesame/Groundnut mixture

| Treatment | 2011 | | | 2012 | | |
|--------------------------------------|------------|---------------|-----------|------------|---------------|-----------|
| Poultry manure (t ha ⁻¹) | LER Sesame | LER Groundnut | Total LER | LER Sesame | LER Groundnut | Total LER |
| 0 | 1.08d | 0.28d | 1.35d | 1.06d | 0.27d | 1.33d |
| 3 | 1.46c | 0.30c | 1.76c | 1.43c | 0.29c | 1.72c |
| 6 | 2.45a | 0.39a | 2.80a | 2.40a | 0.38a | 2.78a |
| 9 | 1.93b | 0.35b | 2.32b | 1.89b | 0.34b | 2.23b |
| SE± | 0.162 | 0.003 | 0.016 | 0.015 | 0.003 | 0.015 |
| Planting Arrangement | | | | | | |
| Single alternate row | 1.71b | 0.28b | 1.99b | 1.68b | 0.27b | 1.95b |
| Double alternate row | 1.74a | 0.38a | 2.12a | 1.71a | 0.37a | 2.08a |
| SE± | 0.011 | 0.002 | 0.012 | 0.011 | 0.002 | 0.011 |

Means followed by the same letter(s) are not statistically different at 5% level of significance.

3.2 Aggressivity (A)

Sesame was more aggressive in the mixture than groundnut at all treatment combinations in both the years (Table 2). The aggressiveness of sesame significantly increased with poultry manure application up to 6 t ha⁻¹ beyond which it significantly decreased in both the years. Similarly, double row planting arrangement significantly increased sesame aggressivity than when planted on single row in all the years. Irrespective of the applied treatments, positive sign of aggressivity for sesame indicated the dominant behavior of sesame over groundnut which had negative aggressivity values.

Table 2. Effect poultry manure and planting arrangement on the aggressivity of sesame/groundnut mixture

| Treatment | 2011 | | | 2012 | | |
|--------------------------------------|----------|-------------|---------|----------|-------------|---------|
| Poultry manure (t ha ⁻¹) | K Sesame | K Groundnut | Total K | K Sesame | K Groundnut | Total K |
| 0 | 0.015d | -0.015a | 0.030d | 0.015d | -0.015a | 0.030d |
| 3 | 0.020c | -0.020b | 0.040c | 0.020c | -0.020b | 0.040c |
| 6 | 0.040a | -0.040d | 0.080a | 0.040a | -0.040d | 0.080a |
| 9 | 0.030b | -0.030c | 0.060b | 0.030b | -0.030c | 0.040b |
| SE± | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Planting Arrangement | | | | | | |
| Single alternate row | 0.025b | -0.025a | 0.055a | 0.025b | -0.025a | 0.050b |
| Double alternate row | 0.028a | -0.028b | 0.050b | 0.028a | -0.028b | 0.055a |
| SE± | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |

Means followed by the same letter(s) are not statistically different at 5% level of significance.

Table 3. Effect poultry manure and planting arrangement on the competitive ratio of sesame/groundnut mixture

| Treatment | 2011 | | 2012 | |
|----------------------|-----------|--------------|-----------|--------------|
| | CR Sesame | CR Groundnut | CR Sesame | CR Groundnut |
| 0 | 4.65c | 0.27a | 4.56c | 0.26a |
| 3 | 5.15b | 0.21b | 5.02b | 0.20b |
| 6 | 5.11b | 0.20b | 5.01b | 0.20b |
| 9 | 7.19a | 0.14c | 7.04 | 0.14c |
| SE± | 0.079 | 0.009 | 0.06 | 0.008 |
| Planting Arrangement | | | | |
| Single alternate row | 6.25a | 0.17b | 6.13a | 0.17b |
| Double alternate row | 4.79b | 0.25a | 4.68b | 0.24a |
| SE± | 0.056 | 0.007 | 0.042 | 0.006 |

Means followed by the same letter(s) are not statistically different at 5% level of significance.

3.3 Competitive Ratio (CR)

The higher CR values for sesame in both the years under different poultry manure rates and planting arrangement compared to groundnut, is an indication that sesame was more competitive than groundnut (Table 4). The lower CR value for groundnut (0.14-0.27) is an indication that it is not a good competitor when grown with sesame.

Table 4. Effect poultry manure and planting arrangement on the area time equivalent ratio of sesame/groundnut mixture

| Treatment | 2011 | 2012 |
|--------------------------------------|-------|-------|
| Poultry manure (t ha ⁻¹) | | |
| 0 | 0.71d | 0.68d |
| 3 | 0.92c | 0.88c |
| 6 | 1.47a | 1.41a |
| 9 | 1.21b | 1.17b |
| SE± | 0.01 | 0.009 |
| Planting Arrangement | | |
| Single alternate row | 1.04b | 1.00b |
| Double alternate row | 1.11a | 1.06a |
| SE± | 0.007 | 0.006 |

Means followed by different letter(s) are statistically different at 5% level of significant.

3.4 Area Time Equivalent Ratio (ATER)

The highest ATER values in both the years (1.47 and 1.41 respectively) were recorded by the application of 6 t ha⁻¹ of poultry manure (Table 4). The lowest values for ATER in the both the years was recorded by the control plots (0.71 and 0.68 respectively). Double alternate row planting arrangement produced significantly higher ATER in both the years compared with single alternate row planting arrangement.

The time (duration) the field was dedicated to production is not considered in the calculation of LER but ATER as proposed by Hiebsch and McCollum (1987) take into consideration the land occupancy period of the crops. The land occupancy period of sesame was 97 days while, that of groundnut was 80 days. Maximum utilization of space and time was observed in plots to which 6 t ha⁻¹ were applied. The better ATER was due to better combined intercropped yield and temporal difference which existed between the crops.

4. Conclusion

From the foregoing, it can be seen that sesame/groundnut intercropping is more efficient than growing either of the crop alone. Sesame was more competitive than groundnut in the mixture because it had higher values for

LER, aggressivity, CR and ATER in all the years of the experiment. The performance of sesame/groundnut mixture was superior when 6 t ha⁻¹ of poultry manure was applied and under double row planting arrangement.

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